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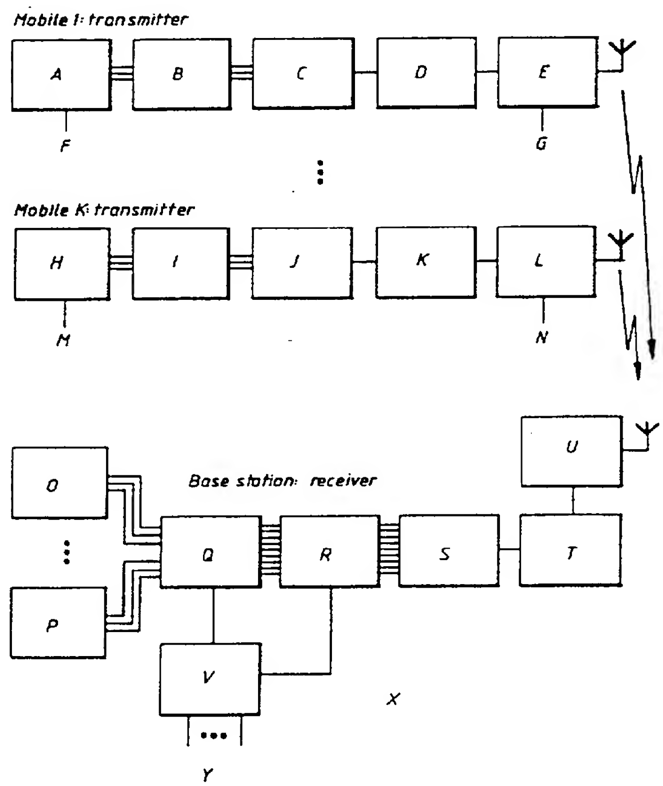
(54) Title: METHOD AND ARRANGEMENT FOR DYNAMIC ALLOCATION OF MULTIPLE CARRIER-WAVE CHANNELS FOR MULTIPLE ACCESS BY FREQUENCY DIVISION MULTIPLEXING

(57) Abstract

The invention relates to a method and an arrangement for dynamic allocation of multiple carrier wave channels for multiple access by frequency division multiplexing. The invention provides a number of mobile units with the possibility of flexible data speed and continuous transmission. On the fixed side, the number of transmitters and receivers can be minimized by utilizing broadband receivers which serve a number of mobiles. According to the invention, a wider frequency band is divided into a number of subbands with a modulated carrier wave in each subband. To vary the transmission speed, such a number of subbands is allocated as is needed by each user in order to cover the data clock requirement. Broadband transmitters/receivers handle the transmission over the entire accessible band. Oversampling is preferably carried out in the frequency demultiplexing in order to permit the best sampling time to be selected for the different frequency gaps.



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TITLE OF THE INVENTION

Method and arrangement for dynamic allocation of multiple carrier-wave channels for multiple access by frequency division multiplexing.

FIELD OF THE INVENTION

The present invention relates to a method for dynamic allocation of multiple carrier-wave channels for multiple access by frequency division multiplexing and transmitter arrangements and receiver arrangements for carrying out the method. The invention is especially intended to be applied to mobile telecommunication systems. The invention provides a number of mobile units with the possibility for flexible data speed and continuous transmission. On the fixed side, the number of transmitters and receivers can be minimized by utilizing broadband receivers which serve several mobile units.

PRIOR ART

In mobile telecommunication systems, it is generally desirable to be able to provide a variable transmission speed in the different connections in order to be able to utilize the accessible frequency band as effectively as possible. In general, the system is provided with a frequency band with fixed width at a certain frequency.

There are a number of known ways to control the utilization of the frequency band, for example TDMA, FDMA, CDMA and hybrids of these.

Time division multiple access (TDMA) involves transmitting and receiving being divided into time gaps. Each channel has its predetermined time gap and the transmission speed can be varied by changing the length of the time gap. A disadvantage is that the system only uses one frequency at a time. TDMA is also sensitive to time dispersion due to the high channel data speed.

Frequency division multiple access (FDMA) involves the frequency band being divided into frequency gaps with one transmitter/receiver in each narrow

band with a carrier wave in the centre of the frequency gap. If it is attempted to increase the data speed by widening the carrier wave, interference is produced in adjacent frequency gaps, which is naturally a disadvantage. Moreover, it is uneconomical to have one transmitter for each frequency gap, which makes for a large number of transmitters.

Code division multiple access (CDMA) involves all channels using the same frequency band but being distinguished by each mobile unit having its own unique code key with which the data sequence is coded. CDMA gives rise to very complex receivers and also requires control of the transmitted power.

SUMMARY OF THE INVENTION

The present invention is mostly related to FDMA in that a wider frequency band is divided into a number of subbands with a modulated carrier wave in each subband. To vary the transmission speed, a user will be able to allocate as many subbands as he needs for covering his data clock requirement. It should also be possible to vary this allocation of subbands with time. Instead of having one transmitter/receiver in each subband, however, broadband transmitters/receivers are used which handle transmission over the entire accessible band.

Thus, the present invention provides a method for dynamic allocation of multiple carrier-wave channels where the bit stream or bits streams which will be transmitted are subjected to conversion from serial form to parallel form with a number of outputs, each parallel output is allocated a frequency gap with a defined subcarrier wave, each subcarrier wave is subjected to symbol coding by being modulated by the respective parallel bit stream in order to provide a number of parallel symbols or parallel subcarrier waves. The parallel symbols are converted by inverse discrete Fourier transform to a sequence in the time domain, which sequence is D/A-converted to provide a baseband signal. The baseband signal is RF-modulated with a frequency at the centre of the overall accessible frequency band. Thus, a single broadband transmitter handles the transmission of all channels. At the receiver end, the RF signal is demodulated to the baseband, the baseband signal is A/D-converted and the

sample is frequency-demultiplexed by discrete Fourier transform which recreates the signal in frequency gaps. Suitable frequency gaps are selected taking into account the respective user and the signals in these frequency gaps

are symbol-decoded into parallel bit streams which are converted to serial form for recreating the original bit stream.

Frequency demultiplexing is advantageously carried out with oversampling in order to permit the best sampling time to be selected for the different frequency gaps.

The invention also relates to transmitter and receiver arrangements for carrying out the method. The invention is specified in greater detail in the subsequent patent claims.

SHORT DESCRIPTION OF THE DRAWINGS

The invention will be described in detail below with reference to the attached drawings in which:

Figure 1 is a diagram of how the accessible frequency band is divided up in accordance with the present invention,

Figure 2 is a block diagram of transmitters and receivers in the uplink in accordance with the invention, wherein the letters symbolize the following

A: Serial to parallel conversion.

B: Coding of symbols.

C: Frequency multiplexing with IDFT

D: D/A-conversion and filtering

E: RF-modulering

F: Information regarding adjustment of sampling points

G: Information regarding adjustment of carrier frequency and transmission effect

H: Serial to parallel conversion

I: Symbol coding

J: Frequency multiplexing with IDFT

K: D/A-conversion and filtering

L: RF-modulering

M: Information regarding adjustment and sampling time

N: Information regarding adjustment and transmission effect

O: Parallel to serial conversion

P: Parallel to serial conversion

Q: Symbol decoding with compensation for frequency faults

R: Down sampling

S: Frequency demultiplexing with FFT (with overlapping sampling)

T: A/D-conversion

U: RF-demodulering

V: Control logic

X: Back coupling of sampling times for the different subbands

Y: Back coupling of fault in time, frequency and signal strength for each mobile unit

Figure 3 is a block diagram like Figure 2 for the downlink;

AA: Serial to parallel conversion

BB: Serial to parallel conversion

CC: Symbol coding

DD: Frequency multiplexing with IFDT

EE: D/A-conversion and filtering

FF: RF-modulering

GG: Parallel to serial conversion

HH: Symbol decoding

II: Frequency demultiplexing with DFT

JJ: A/D-conversion

KK: RF-demodulering

LL: Back coppling of sampling times

MM: Parallel to serial conversion

NN: Symbol decoding

OO: Frequency demultiplexing with DFT

PP: A/D-conversion

QQ: RF-demodulering

RR: Back coupling of sampling times

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows the situation in, for example, a base station in a mobile telephone system. The base station is provided with a frequency band of, for example, 50 MHz. A number of users k will be served within the frequency band. The different users have different data clock requirements, partly between themselves and partly because their requirement varies with time. According to the invention, the total frequency band is divided into a number m, for example 50, of frequency bands with a subcarrier wave in each frequency gap. Each user is allocated a suitable number of frequency bands. A number of known methods for dividing the frequency band are today available, which are used inter alia for allocating time gaps in a TDMA system. However, the different subcarrier waves are not transmitted by separate transmitters in this case but by a single broadband transmitter, as is explained below with reference to Figures 2 and 3.

Figure 2 shows the uplink situation, that is to say the mobiles transmit to the base station. Each mobile which wishes to transmit has a message in the form of a bit stream. Each frequency gap has a fixed width of, for example, 1 MHz and thereby a limited data transmission speed. Allocation algorithms determine if the bit stream has space in one gap or how many gaps will be used. In general, a number of gaps or subbands are required. The bit stream is therefore first subjected to serial to parallel conversion so that each band is given a suitable data speed. This can be carried out in a known manner, for example by means of a shift register.

In the unused subbands no power is transmitted.

The carrier waves in the subbands are then quadrature modulated with respective parallel bit streams, that is to say the subcarrier waves are subjected to symbol coding. Any suitable known modulation method can be used, for example BPSK, QPSK, QAM. The method has n bits/symbol and the modulation clocks 1 symbol/second (baud) which implies that the gross bit

clock in each subband is n * 1 bits/second. This provides a number of parallel symbols or wave forms, that is to say parallel modulated subcarrier waves. These parallel symbols are found in the frequency domain. In gaps which will not be used a zero is applied.

These parallel symbols are obtained as a sequence in the time domain by an inverse discrete Fourier transform (IFDT) with m points. The sample sequence obtained is then further sampled by narrow-band filtering. It will be observed that, since the analog part of the transmitter only has broadband filtering, the filter must be of the band-pass type for minimizing transmitted power in non-allocated frequency gaps. Furthermore, the filter must be adaptive so that its band width can be changed when more or fewer frequency gaps are allocated. The sequences are sampled the same number of times per symbol time as there are subcarrier waves.

The sequence is then subjected to D/A conversion. This provides a single time-continuous analog baseband signal which fills up the complete allocated frequency band.

The baseband signal can then be RF-modulated in a conventional manner at the centre frequency of the overall band, for example 900 MHz. The carrier wave frequency and output power can be adjusted at an RF modulator of the mobile in order to compensate for frequency error and to provide for power control for reasons which will be specified below.

In the receiver at the base station, first the received radio signal is converted to base band in the conventional manner by means of an RF demodulator. The baseband signal is A/D-converted.

To get back in the modulated subcarrier waves in the frequency domain, frequency demultiplexing is carried out by discrete Fourier transform (DFT) with m points. The choice of the "window" for this DFT determines the sampling times for the symbols in the subcarrier waves. This must be selected in such a manner that a maximum eye opening is obtained at the sampling time. Since the different mobiles are not synchronized to one another or at least only roughly synchronized, they will have different optimum sampling times. By carrying out frequency demultiplexing with oversampling, different

sampling times can be selected independently of one another for the different mobiles. Oversampling is obtained by the DFT being taken via a multiple overlapping window. Oversampling can be, for example, 2, 4 or 8 times. The more accurately the mobiles can be synchronized, the lower the oversampling

required. Higher oversampling makes higher demands on a fast Fourier transform.

After that, the sequence obtained is sampled down, which involves the best sample (the window) being selected for a respective frequency gap. This is produced by feedback from the symbol decoding following. Higher layers report which frequencies belong to which user.

The symbol decoding is done in parallel for the different gaps. Since receivers and transmitters are not synchronized, the right sampling time must be selected, hence the oversampling. The best point is selected as mentioned above.

To minimize interference between the signals received from different mobiles, the frequency error of the mobiles must also be kept within certain limits. Moreover, their output power must be adjusted so that all mobiles set the transmitted power level in such a manner that the received levels at the base stations become essentially identical. In the symbol decoding, errors in frequency and power are therefore measured which are fed back to the respective mobiles by the associated control logic. A number of known methods are available for this. Furthermore, errors in the sampling time are fed back to the unit which selects which sample will be used for the respective mobile.

This is followed by a parallel-to-serial conversion for the frequency gaps which belong together. This recreates the original bit streams.

Figure 3 shows the downlink configuration. The transmitter in the base station is mainly the same as the transmitters in the mobile stations. One difference is that the base station serves a number of users. Thus, serial-to-parallel conversion is carried out for each user. Higher layers handle the allocation of frequency gaps. It is also assumed that the transmitter has a stable carrier wave

frequency. There is a possibility of transmitting at different power in different frequency bands in order to adapt the power to the different receivers which are generally located at different distances from the base station.

The receivers in the mobile stations are simplified compared with the receivers in the base station. Since each mobile generally only receives signals from one base station, there is no problem with different synchronizations in the received signal. It is therefore not necessary to carry out oversampling in frequency demultiplexing in the mobile. Instead, the sampling time is selected on the basis of a feedback from the subsequent symbol decoder. The window can thereby be set to a suitable time which, of course, is the same for all frequency bands since they are transmitted from the same transmitter, namely the base station, and received at the one place in the mobile.

It must be pointed out that it is not necessary for there to be the same number of gaps in the uplink and downlink. Asymmetric data traffic is thus possible, for example, with 10 kbit in one direction and 50 kbit in the other. The higher layer has access to a logic channel for signalling. Here, information about allocation of channels, type of transmission, synchronization etc. is exchanged, as is known in the field.

Thus, the present invention provides a novel system for the allocation of multiple carrier wave channels by frequency division multiplexing which utilizes Fourier transform and oversampling. An advantage of placing high data clocks in a number of parallel frequency bands is that the symbol clock becomes lower and with it the sensitivity to time dispersion. The protective scope of the invention is limited only by the patent claims following.

PATENT CLAIMS

1. Method for dynamic allocation of multiple carrier wave channels, characterized by the following steps in the transmitter:

that at least one bit stream is subjected to conversion from serial form to parallel form with a number of outputs;

that each parallel output is allocated a frequency gap with defined subcarrier wave;

that each subcarrier wave is subjected to symbol coding by being modulated with the respective parallel bit stream, a number of parallel symbols being obtained;

that the parallel symbols are converted by inverse discrete Fourier transform to a sequence in the time domain;

that the sequence is D/A-converted which provides an essentially time-continuous baseband signal;

that the baseband signal is RF-modulated with a frequency at the centre of the overall accessible frequency band;

and by the following steps in the receiver:

that the RF signal is demodulated to the baseband;

that the baseband signal is A/D-converted;

that the sample is frequency-demultiplexed by discrete Fourier transform, which provides a division of the signal in frequency gaps;

that suitable frequency gaps are selected;

that the signals in these frequency gaps are symbol-decoded into a number of parallel bit streams; and

that these parallel streams are converted to at least one serial bit stream in correspondence with an original bit stream.

2. Method according to Claim 1, characterized in that the symbol decoding provides a feedback for adjusting the sampling time in the frequency demultiplexing.

3. Method according to Claim 2, characterized in that the receiver receives signals from a number of transmitters; comprising the further steps:

that oversampling is carried out in the frequency demultiplexing;

that the best sampling time for the respective frequency gap is selected with the aid of feedback from the symbol decoder.

4. Method according to any of the preceding claims, characterized in that information is fed back from the symbol decoding to the RF modulation for adjusting the carrier wave frequency and output power.

5. Transmitter arrangement with dynamic allocation of multiple carrier wave channels, characterized by

an arrangement for serial-to-parallel conversion of at least one bit stream per a number of outputs;

an arrangement for symbol coding of subcarrier waves with respective parallel bit streams;

an arrangement for frequency-division multiplexing of the subcarrier waves by inverse discrete Fourier transform into a sequence in the time domain;

an arrangement for D/A conversion of the sequence into an essentially time-continuous baseband signal; and

a modulation arrangement for RF modulation of the baseband signal.

6. Receiver arrangement for dynamic allocation of multiple carrier wave channels, characterized by

a modulation arrangement for demodulating an RF signal to the baseband;

an arrangement for A/D conversion of the baseband signal into a digital signal;

an arrangement for frequency demultiplexing by discrete Fourier transform of the digital signal so that it is distributed to the frequency gaps;

an arrangement for symbol decoding of the signals in each frequency gap into parallel bit streams;

an arrangement for parallel-to-serial conversion of selected bit streams.

7. Receiver arrangement according to Claim 6, characterized in that the symbol decoding arrangement is fed back to the frequency demultiplexing arrangement for adjusting the sampling times.

8. Receiver arrangement according to Claim 5 or 7, characterized in that the frequency demultiplexing arrangement carries out oversampling and that the receiver arrangement also comprises a step-down sampling arrangement to which the symbol decoding arrangement is fed back so that the step-down sampling arrangement can select the best sampling time for the respective frequency gap.

Fig.1

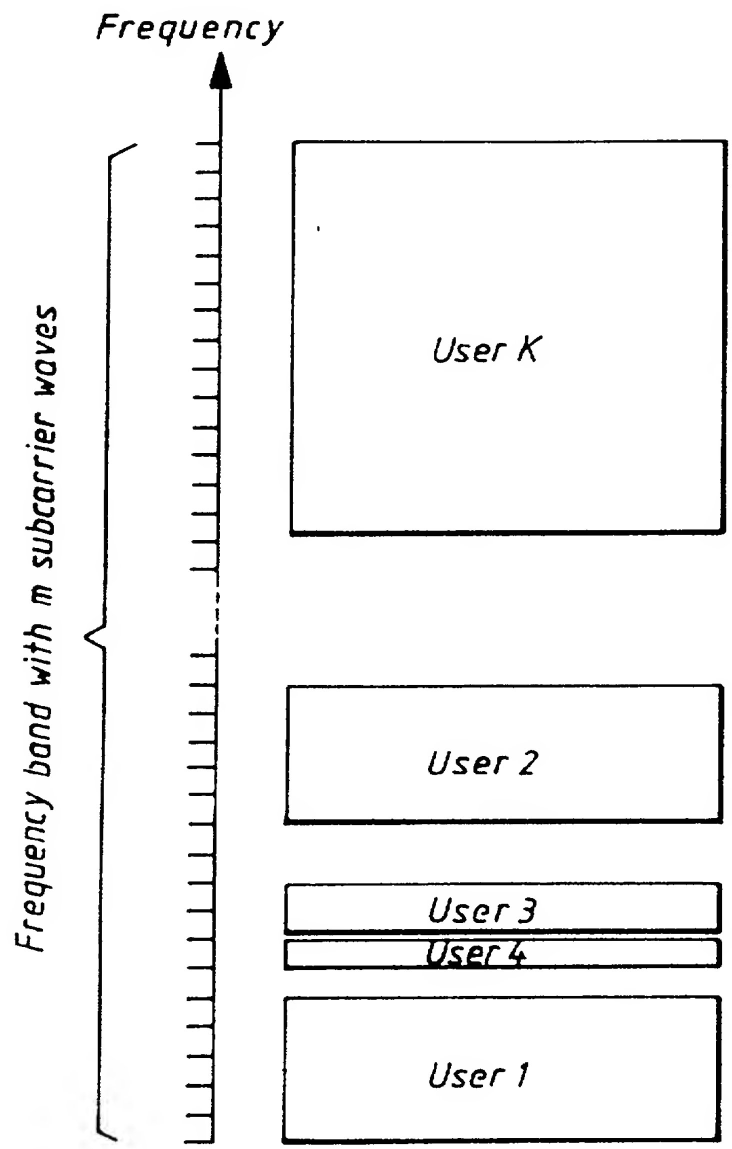

Frequency
Frequency band with m subcarrier waves
User K
User 2
User 3
User 4
User 1

Fig. 2

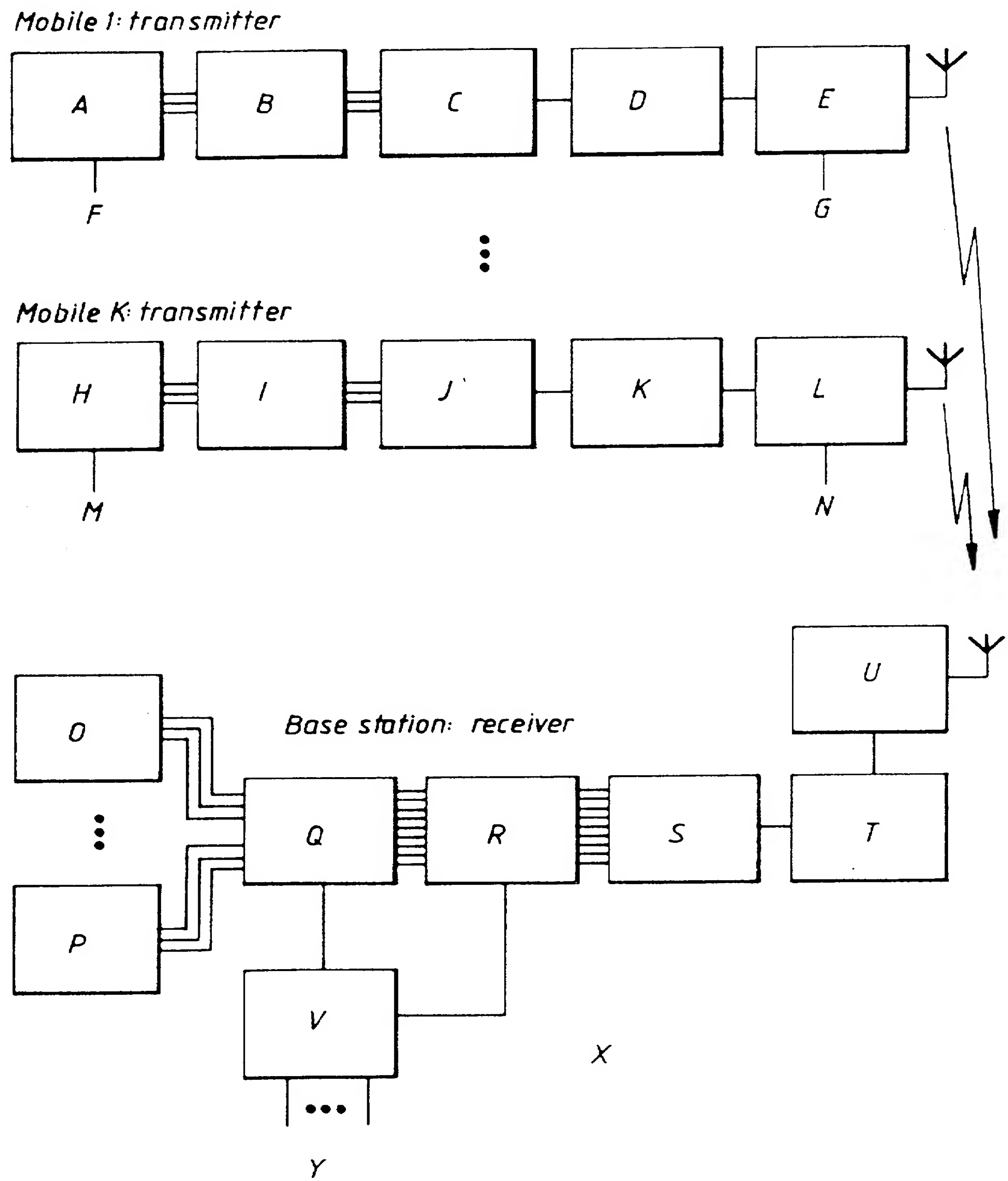
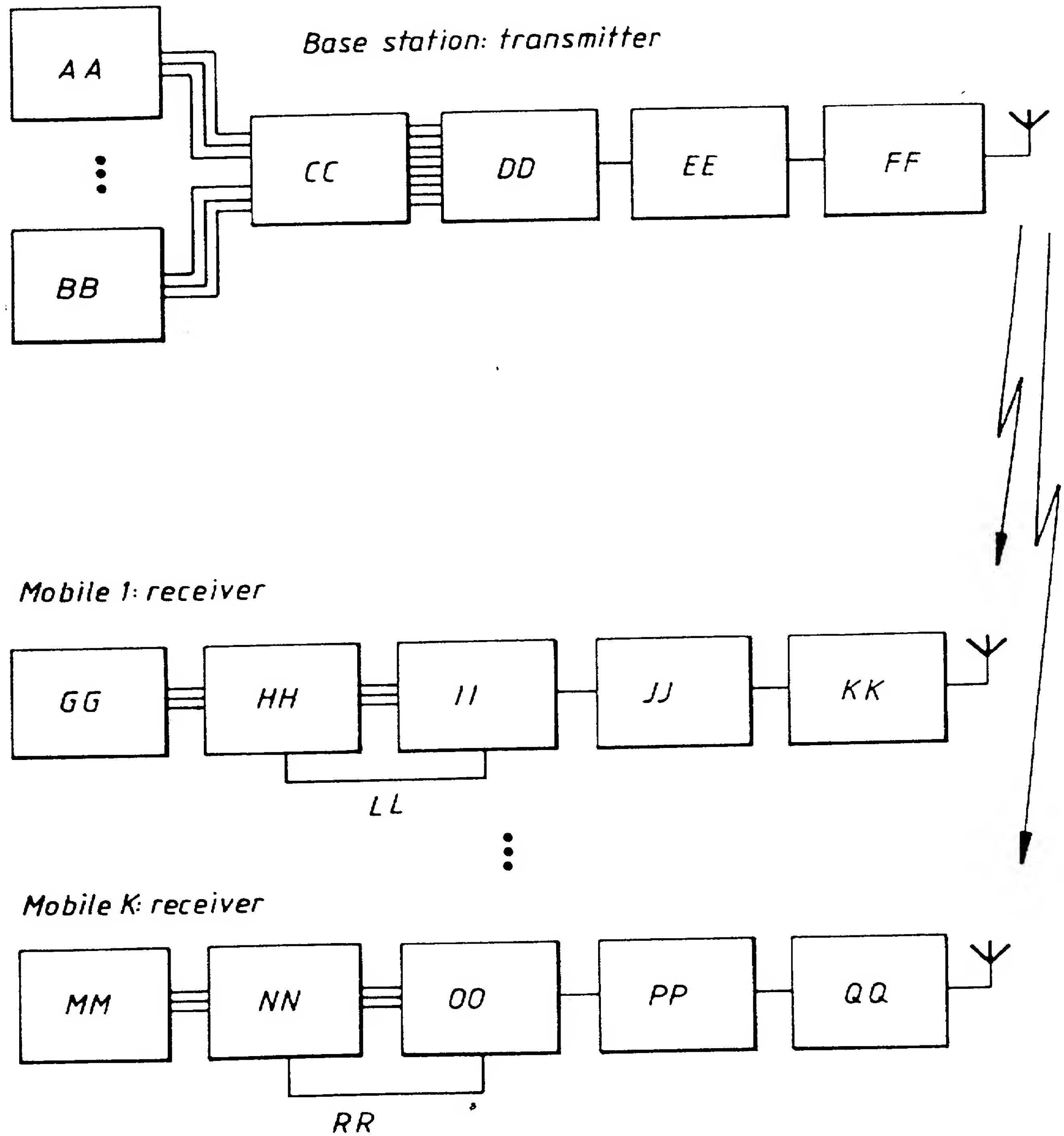

Mobile 1: transmitter
A
B
C
D
E
F
G
Mobile K: transmitter
H
I
J
K
L
M
N
Base station: receiver
O
P
Q
R
S
T
U
V
X
Y

Fig.3


Base station: transmitter
AA
BB
CC
DD
EE
FF
Mobile 1: receiver
GG
HH
II
JJ
KK
LL
Mobile K: receiver
MM
NN
OO
PP
QQ
RR

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 93/00941

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: H04J 1/00, H04J 4/00, H04Q 11/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: H04J, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Patent Abstracts of Japan, Vol 7,No 94, E-171, abstract of JP, A, 58-17743 (MITSUBISHI DENKI K.K.), 2 February 1983 (02.02.83) -- --------	1,5

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

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